

# **Examination of the Utility of Less-than-Lethal (LTL) Systems in an Exercise Simulated with the Joint Tactical Simulation (JTS)**

**Doug Magnoli**  
**Lawrence Livermore National Laboratory**

**6 June 1997**

This work was performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48. This study was sponsored by the Commandant's Warfighting Lab under the provisions of a non-DOE Work for Others agreement.

## Executive Summary

The purpose of this project was to develop an initial method for studying the effects of less-than-lethal (LTL) systems on conflict, using the Joint Tactical Simulation (JTS) and to conduct a preliminary examination of the utility of LTL systems on the outcome of a specific scenario. The scenario examined was MegaGold, a Army exercise conducted without LTL weapons, with the goal of determining how the use of LTL systems in that exercise might have affected the engagement. The objective of MegaGold is for an Air Assault Battalion to clear a small village, containing both combatants and civilians, of enemy combatants.

Our initial model of the effects of LTL weapons, which was incorporated into JTS, defines a duration of personnel incapacitation as a function of which LTL weapon was used and range of target from the weapon. While incapacitated, an entity cannot move or shoot. In a confrontation where lethal force is to be avoided (such as against the civilians in MegaGold), LTL systems give Blue forces the flexibility to incapacitate without killing.

Red forces in the scenario include 21 troops, predominantly riflemen armed with AK-47s, but also including machine gunners and a sniper. Blue forces consist of three platoons of Marine infantry, together with another team. Blue troops numbered 124 in the scenario and included riflemen, grenadiers, semi-automatic weapon gunners, platoon leaders, and others. There were 50 civilians in the scenario, armed with rocks. Rocks thrown at Blue forces could incapacitate.

LTL systems used in the scenario included both ballistic systems (e.g., foam batons, bean bags) and chemical irritants (such as OC spray). The scenario was run four times without the LTL systems, and four times with them, and the results from the two sets of runs were compared, as shown in Table E-1. Although a total of eight runs is generally not enough to draw any statistically significant conclusions, time constraints prevented our doing more. Our hope was that these eight runs would bring some of the larger differences to light.

Examination of Table E-1 shows differences in numbers of Blue casualties, Red casualties, and Blue shots taken at civilians between the cases where LTL systems are and are not available. The difference in Blue casualties with and without LTL is significant at the 90% confidence level; the difference in Red casualties is significant at the same level. A greater number of runs might have shown a higher statistical significance; I estimate that approximately 20 runs would be needed for each case (with and without LTL) to make a stronger statement about the significance of these differences.

The difference in total number of shots fired by Blue is significant to beyond the 98% confidence level, as is the difference in number of lethal Blue shots fired at civilians. This result suggests that when Blue does not have LTL systems, Blue is at a loss for dealing with troublesome rock-throwing civilians. When LTL systems are available, Blue can engage the civilians—incapacitating them and getting them out of the way—with minimal danger of killing them.

Table E-1  
Average values from running scenario MegaGold in JTS  
with and without LTL systems

	Without LTL	With LTL
Blue casualties	33.3	21.5
Red casualties	11.8	15.3
Civilian casualties	1.5	0.8
Lethal Blue shots at civilians	21	2
LTL Blue shots at civilians	0	241

While this is a significant result, further work would allow us to explore many other fruitful areas. In MegaGold, for example, Red was greatly outnumbered by Blue. Furthermore, civilians in this exercise were not generally enough of a problem to Blue forces to warrant use of lethal force against them—if they had been, we would expect to find that civilian deaths decrease when LTL systems are made available to Blue. Some of the questions we would like to answer are:

- what happens when Red and Blue are more evenly matched?
- what happens in a scenario where civilians are more of a problem to Blue forces?
- which LTL weapons are most effective, either alone, or as part of a weapons mix?
- which LTL systems allow Blue to accomplish his objective in minimal time, with minimal civilian deaths?

MegaGold was not designed to answer these questions—it was a scenario of opportunity. It is to be hoped that further work will provide us the opportunity and resources to be able to study scenarios specifically designed to study the issues of most interest to the LTL community.

## **Introduction**

The purpose of this project was to incorporate algorithms describing the behavior of less-than-lethal (LTL) systems into a version of the Joint Tactical Simulation (JTS), a high-resolution, entity level, force-on-force battle simulation, and to conduct a preliminary examination of the utility of LTL systems on the outcome of a specific scenario. Consistent with the requirements of the Commandant's Warfighting Lab, the scenario examined was MegaGold, an Army exercise conducted at Ft. Campbell which was to have involved LTL systems. Because permission to use LTL munitions in the exercise was withdrawn, actual LTL use in MegaGold was not examined. This simulation analysis of MegaGold is therefore the only study of the use of LTLs related to that exercise.

## **Modification of JTS to include LTL effects**

It was decided that duration of personnel incapacitation as a function of weapon and range from weapon would constitute our initial model of LTL systems. While incapacitated, an entity is unable to move or to shoot. Two kinds of weapons are defined in the code: point effect weapons (such as rubber bullets), for which the relevant range is how far the target is from the shooting system, and area effect weapons, such as UAV-deployed pepper spray or whistlers, where the relevant parameter is distance of the victim from where the system was deployed, independent of where it was shot from. Data for a particular LTL system are entered as triplets of range (in meters), incapacitation time (in seconds), and standard deviation of incapacitation time (in seconds).

In addition to these agreed upon changes, the code was also modified to allow a LTL weapon to deplete its target's energy supply. (The JTS model allows assignment of an energy level to each entity, and energy is expended each time the entity does something.) This data also is entered in triplets of range (meters), energy depletion (cal), and standard deviation (cal). The energy depletion feature was not used in exercise MegaGold. A detailed description of how to use the model is included in Appendix A.

## **Simulation of Exercise MegaGold**

In MegaGold, the objective is for an Air Assault Battalion to clear a small village, containing both combatants and civilians, of enemy combatants. Because local goodwill is desired, civilian casualties are undesirable. LTL

systems for the scenario included both ballistic systems and irritants, which are direct fire, point effect weapons.

Figure 1 shows a diagram of the village used for the exercise. Appendix B provides both a detailed description of Marine actions in the village and a set of diagrams illustrating the planned mission, which was to secure the village. This was accomplished by Marine units moving from building to building.

Red forces in the scenario include 21 troops, 7 regulars training 14 militiamen. Red units are predominantly riflemen armed with AK-47s, but also include machine gunners and a sniper.

Blue forces consist of three platoons of Marine infantry, called first, second, and third platoons in the scenario (Appendix B), together with another team called Team Wardog. The three platoons contained trucks and helicopters; Team Wardog had UAVs. Excluding vehicles, Blue troops numbered 124 in the scenario and included riflemen, grenadiers, semi-automatic weapon (SAW) gunners, platoon leaders, medics, and others. In the non-lethal runs of the scenario, Blue units carried not only their lethal munitions, but also non-lethal munitions which could be used with the same weaponry. Because Blue was not to engage civilians lethally unless absolutely necessary, it was decided that Blue would not shoot lethal systems at civilians unless the civilians were within 5 meters of the Blue unit.

There were 50 civilians in the scenario. Civilians were armed with rocks. Rocks were modeled as LTL systems with a maximum range of 50 feet and the ability to incapacitate for an average of 49 seconds. (See Appendix C for the data on LTL systems.)

### Process

Eight runs of JTS were made, four without LTL systems and four including them, with Marine lieutenants interactively playing Red and Blue. A civilian contractor played the civilian forces. Each scenario took approximately two hours of game time to run. Because of computer system problems, some of the eight runs were not completed. Table 1 shows game time for each of the runs. A complete run took 110 to 120 minutes; those runs which are shorter than that were not completed due to computer problems.

353

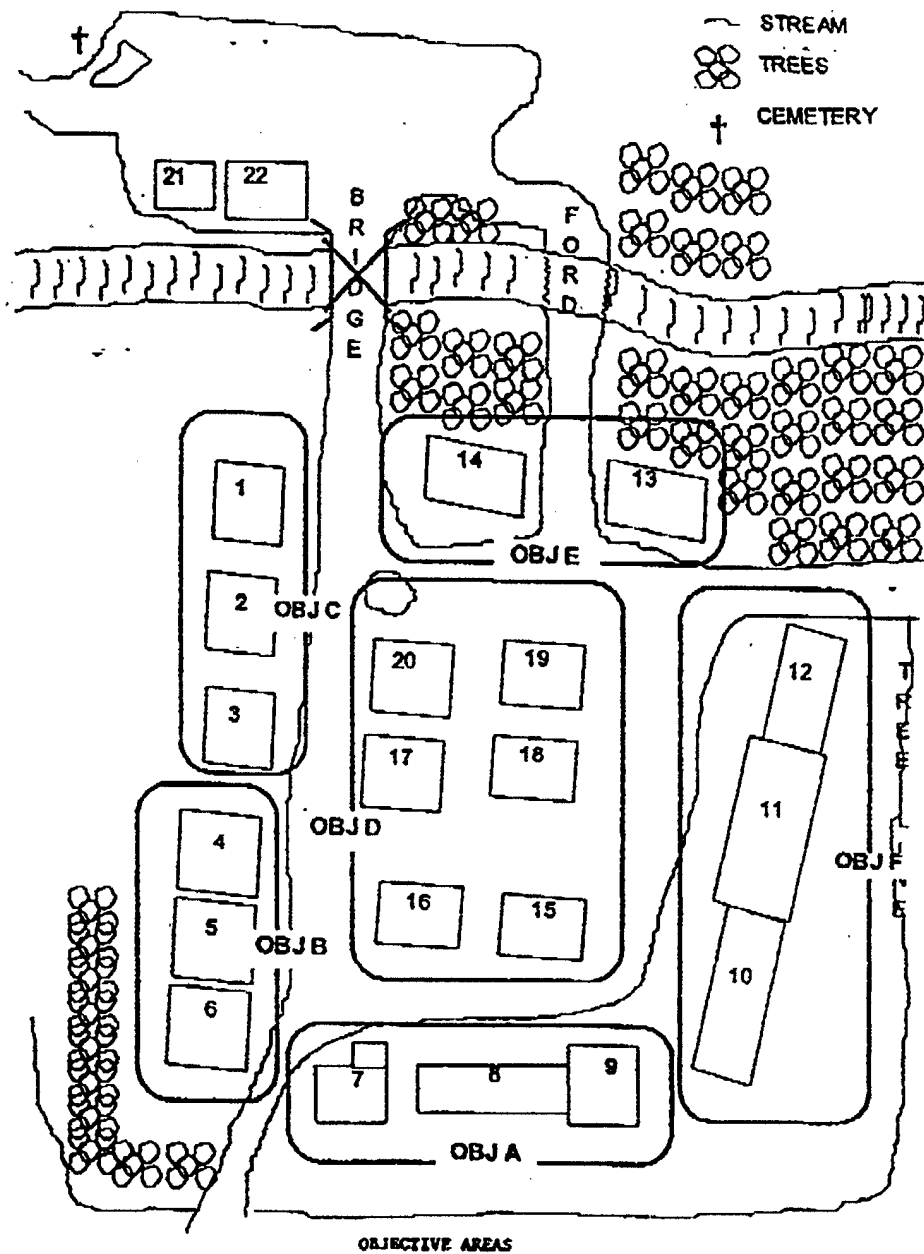


Figure 1. Diagram of the village used in exercise MegaGold, showing the Marines' objective areas. Further details can be found in Appendix B.

Table 1  
Run times for the scenarios

Scenario number	Run time (minutes)
16a	110.32
16p	83.70
17a	115.70
17p	120.19
18a (LTL)	38.27
18p (LTL)	57.21
19a (LTL)	113.54
19p (LTL)	113.60

The scenarios are labeled according to when they were run: scenario 16a, for example, was run on the morning of the 16 December, 1996. The table clearly indicates that scenarios 16p, 18a, 18p were unable to finish. In all runs where the scenario was completed, the Blue mission was accomplished.

Appendix C lists the LTL equipment carried by Blue units and the data used to describe the LTL systems. This data was collected from police departments by the Naval Surface Warfare Center. It is noteworthy that none of the systems is, according to the data, effective at ranges greater than 15.2 m, and that all the point effect systems have incapacitation times under 80 seconds, although some of the area effect systems can incapacitate up to an hour.

## Results

Table 2 presents casualties for each run. Red and civilian casualties are due to Blue fire; Blue casualties are due to Red fire.

Table 2  
Casualties for each run

Scenario number	Casualties		
	Blue	Red	Civilian
16a	13	11	1
16p	45	12	1
17a	50	12	1
17p	25	12	3
18a (LTL)	5	10	0
18p (LTL)	16	9	0
19a (LTL)	37	21	0
19p (LTL)	28	21	3
Avg (St Dev) no LTL	33.25 (17.3)	11.75 (0.5)	1.5 (1.0)
Avg (St Dev) with LTL	21.5 (14.0)	15.25 (6.7)	0.75 (1.5)

Notice that scenarios 18a and 18p show fewer casualties than the others. This is attributable to computer problems which did not allow the scenarios to finish. Although scenario 16p did not finish, Red made an early attack on Blue's 1st platoon early in the game, explaining the high Blue casualties.

Because of the way this scenario was played, and particularly because the civilians were not, for the most part, greatly irritating to Blue, few civilians were killed in both the lethal and LTL cases.

Although it is interesting that availability of LTL weapons to Blue appears to have resulted in fewer Blue casualties and more Red casualties, these casualty differences are statistically significant only to the 90% confidence level. More runs of the scenarios might have allowed stronger conclusions about the significance of these differences. I estimate that approximately 20 runs each of the scenarios with and without LTL weapons might show significance at the 95% level. (Statistical significance at the X% level means that only 100-X% of the time will the conclusion that the two things are different be in error, because the appearance of difference is due only to chance.

Differences in civilian casualties are not statistically significant. (A lack of statistical significance means that the data do not support the conclusion that civilian casualties are different with and without LTL systems at any "high" (say, more than 70%) confidence level.) In order to see a significant difference in civilian casualties, we would need to examine a scenario where civilians



were more of a problem to Blue, so that Blue would be engaging them even without LTL weapons (i.e., killing them).

Table 3 presents engagements of Blue forces on civilians for each scenario.

Table 3  
Blue shots at civilians

Scenario number	Number of shots
16a	15
16p	4
17a	4
17p	62
18a (LTL)	114
18p (LTL)	144
19a (LTL)	346
19p (LTL)	368
Avg (St Dev) no LTL	21 (27.7)
Avg (St Dev) with LTL	243 (132.5)

On average, Blue engagements of civilians increased by an order of magnitude when LTL weapons were available to Blue forces. Without knowing anything about the distributions of Blue engagements and using rank information only (which gives a conservative estimate of the statistical significance of this difference), the difference is significant at the 98% confidence level.

Table 4 lists the LTL munitions used in the scenario and presents the average number of LTL shots fired (and how many civilians were incapacitated by them) for each LTL munition.

Table 4  
Number of LTL munitions shot at civilians  
(Averaged over the four LTL runs)

Munition	Average number fired	Average no. incapacitations	Incapacitations per shot
DT23BR 12G Bean Bag	46	15	0.326
DT23FS 12G Fin Stab.	102	37	0.363
DT40A Stinger	23	11	0.478
DT40B Stinger	12	5	0.417
DT40F Foam Baton	9	1	0.111
DT40W Wood Baton	32	14	0.438
MK4 OC Spray	15	9	0.600
MK9 OC Spray	2	1	0.500
Stinger Grenade 15*	7	3	
Total direct fire*	241	93	0.386

\*The stinger grenade is considered an indirect fire system and is capable of incapacitating more than one target per round. Stinger Grenade shots are not included in this total.

Although it appears that the Mk4 and Mk 9 OC Spray may be more effective than the other LTLs, and that the DT40F Foam Baton may be less effective than the others, statistical tests do not support such conclusions: more data is necessary before we can reliably determine which LTL systems are more effective than others in the simulation. Such data would include more (at least 30) shots of each weapon. It would also be useful to put each weapon, individually, in a certain role and compare the results for various weapons to learn which weapon best suits which military role.

The data provided by the current version of JTS includes a record describing an entity's incapacitation and what it is due to, but it does not include how long the entity is incapacitated. Although most of the LTL systems incapacitate for similar lengths of time (31 to 76 sec), the OC Sprays incapacitate for 15 minutes to an hour and thus could be deemed more effective for that reason.

Subtracting the average LTL firings (241) from the average number of shots fired by Blue on civilians (243, from Table 3) reveals that Blue fired an average of two lethal shots when LTL weapons were available, approximately

one-tenth as many as when LTL weapons were not available (21, from Table 3). The finding here is that when LTL weapons are available, Blue shoots lethal weapons only rarely: 99% of Blue shots at civilians are LTL.

Table 5 shows the number of rocks civilians hurled at Blue forces in each scenario.

Table 5  
Number of rocks thrown by civilians at Blue forces

Scenario number	Number of rocks
16a	48
16p	24
17a	64
17p	95
18a (LTL)	12
18p (LTL)	5
19a (LTL)	57
19p (LTL)	82
Avg (StDev) no LTL	58 (29.8)
Avg (St Dev) with LTL	39 (36.8)

The apparent drop in the number of rocks thrown when Blue forces had access to LTL systems is probably an artifact of scenarios 18a and 18p ending before the part of the scenario where most of the rocks are thrown. The difference in number of rocks thrown in the scenarios with and without LTL weapons is not statistically significant, even taking into account that scenarios 18a and 18p ended early. None of the rocks had any effect in killing or suppressing Blue units.

## Conclusions

Examining the numbers in the tables above leads to the discovery that the availability of LTL systems allows Blue to engage civilians in arenas where Blue would otherwise be unable to act. That the number of direct fire

engagements against civilians increases by a factor of 12 when LTL systems are available indicates that LTL systems give Blue forces the flexibility to deal with civilian distractions in cases where the distraction is not sufficient to warrant lethal force.

Although Table 2 indicates that Blue losses decrease when LTL systems are present (from an average of 33 to 21), this may be a consequence of the early termination of some of the LTL scenarios and is statistically significant only at the 90% level. The finding that Red losses increase (from an average of 12 to 15) when LTL weapons are present is significant at the same level. A greater number of runs might have shown a higher statistical significance; I estimate that approximately 20 runs would be needed for each case (with and without LTL) to make a stronger statement about the significance of these differences.

Because the civilians in this exercise were not generally enough of a problem to Blue forces to warrant lethal force against them, the difference in number of civilian deaths as a function of availability of LTLs is inconsequential. If we had studied a scenario where civilians posed more of a problem to Blue, it is to be anticipated that the introduction of LTLs might have allowed Blue to deal with troublesome civilians in a non-lethal manner, sparing civilian lives relative to the case where Blue is limited to a choice of using or not using only lethal weapons. This is likely to be a fruitful area for later studies.

The scenario chosen for this exercise was one where Blue accomplishes its mission handily both with and without LTL weapons. A scenario where Blue and Red forces are more evenly balanced, and where the successful accomplishment of Blue's objective is not certain, might more readily show differences in mission accomplishment or civilian casualties between the cases where LTL systems are available or not. Further work could productively explore the extent to which having LTL weapons makes a difference in casualties on each side when Red and Blue are more evenly balanced.

A study such as this raises many questions, such as:

- which LTL systems are most effective both individually and as components of various weapons mixes?
- does the availability of LTL systems result in fewer Blue or civilian casualties?
- Can the military objective be accomplished more quickly with certain LTL systems or mixes?

This is hardly an exhaustive list. Such an analysis could be done by varying the LTL systems available to the Blue force and examining the results.

For this analysis, we were given an exercise (MegaGold) and asked to study the effects of including LTL systems. A more productive piece of work, from the standpoint of being able to answer specific questions about the effects of LTL systems, would begin with a scenario tailored to the study of those systems and would allow sufficient time to do many JTS runs. With such a scenario and a few weeks for running the simulation, we expect that we would be able to address many of the issues raised in this report.

### **Acknowledgements**

This work would not have been possible without the excellent and professional support provided by the very knowledgeable JTS team (headed by Mr. Joe Flores and Maj. John Kelly) at Quantico, who actually did the runs and provided us with their results.